



BASIC RESEARCH IN PLASMA- ENHANCED CPMBUSTION

4 November 2009

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Program Manager

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Air Force Research Laboratory

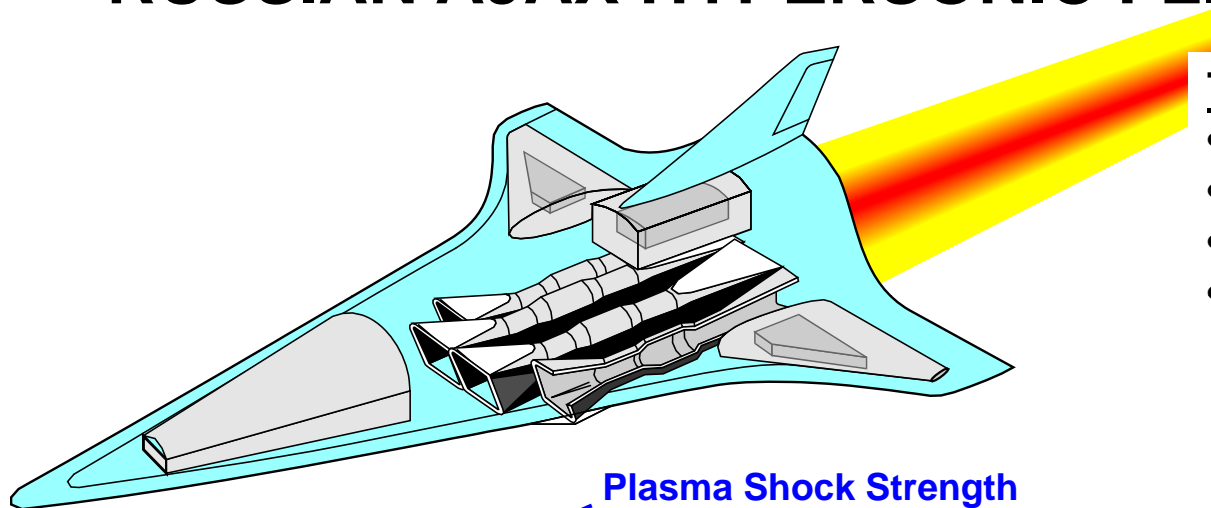
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PLASMA DYNAMICS FOR AEROSPACE APPLICATIONS

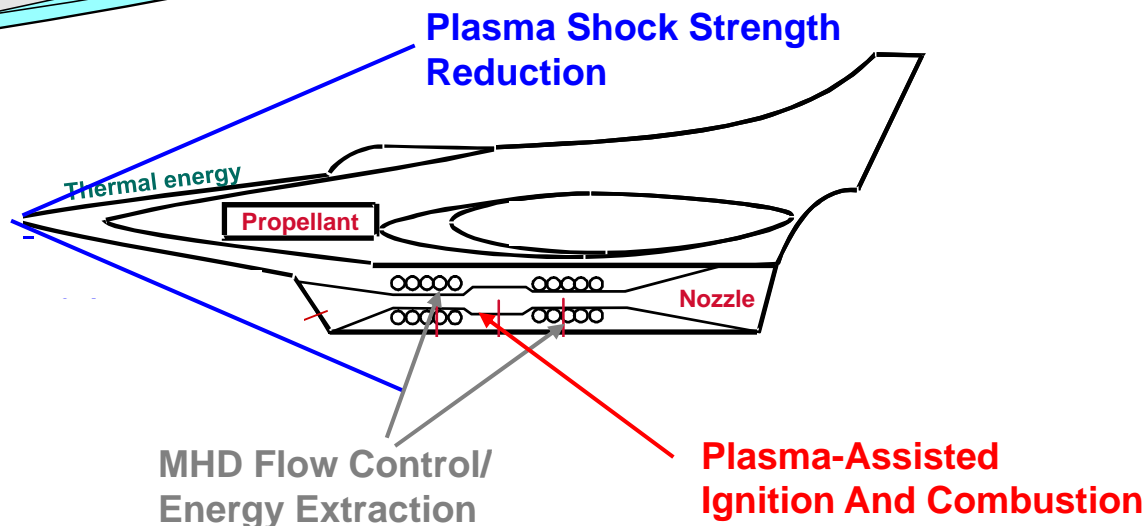


RUSSIAN AJAX HYPERSONONIC FLIGHT VEHICLE (1994)



TECHNICAL CHALLENGES

- Uniform Plasma Generation
- Power Required; System Impact
- High Re, Q Environment
- Measurement/Modeling

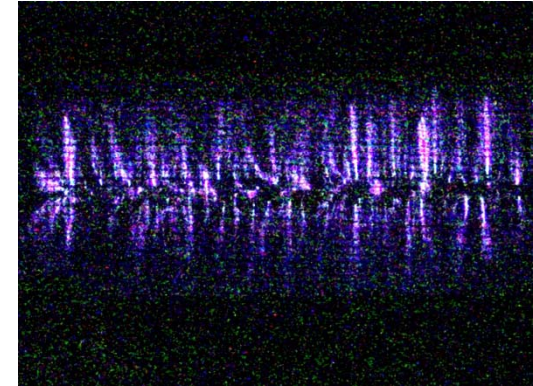
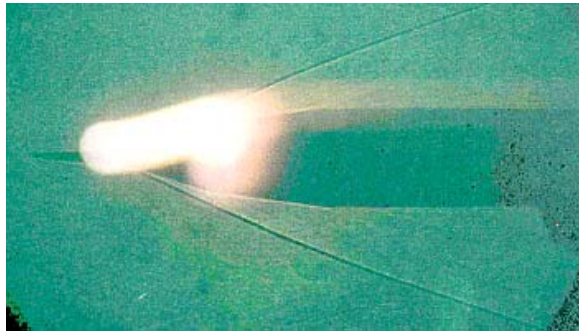


PAYOFFS

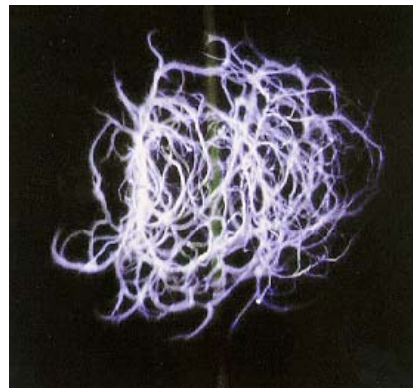
- Drag Reduction
- Thermal Management
- Flight Control
- Size, Weight reduction
- Few Moving Parts
- Power generation
- Ignition/Combustion Enhancement



PLASMA DYNAMICS FOR AEROSPACE APPLICATIONS

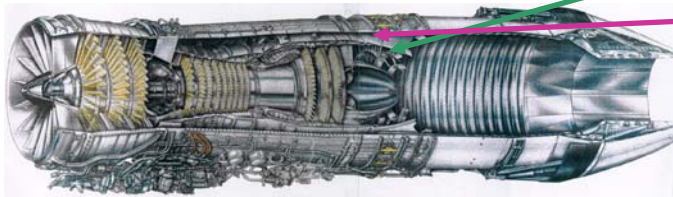
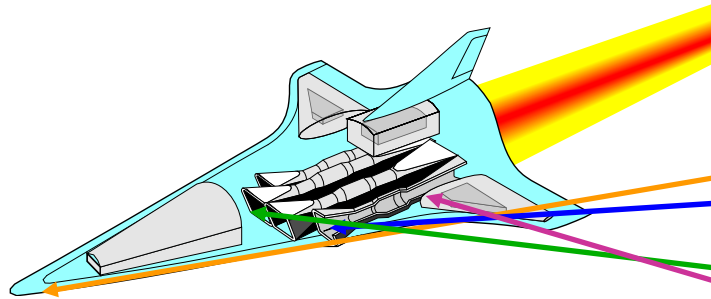


THEME OBJECTIVE: Understand, Predict, And Control Weakly Ionized Flows To Revolutionize The Performance Of Aerospace Vehicles





PLASMA DYNAMICS FOR AEROSPACE APPLICATIONS



RESEARCH

- Aerodynamic Drag Reduction
- MHD Flow Control
- Glow Discharge Flow Control
- Plasma Generation
- Ignition / Combustion Enhancement

AFOSR PROGRAM MANAGER TEAM

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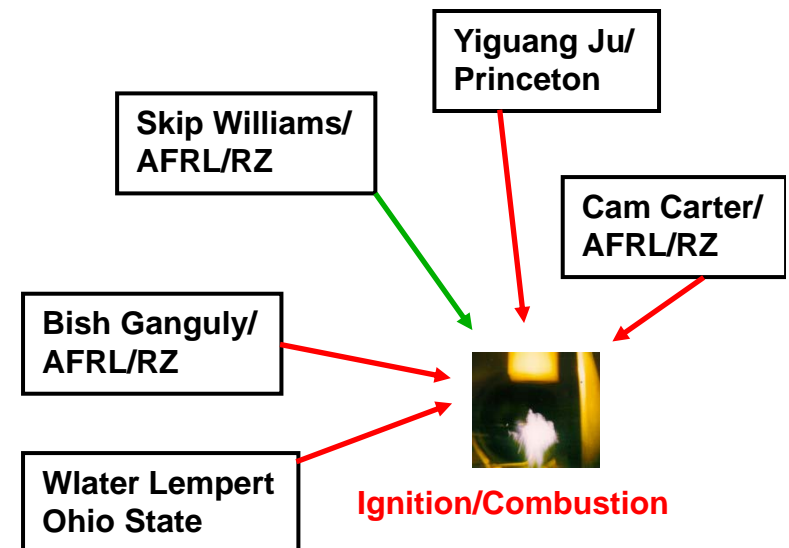
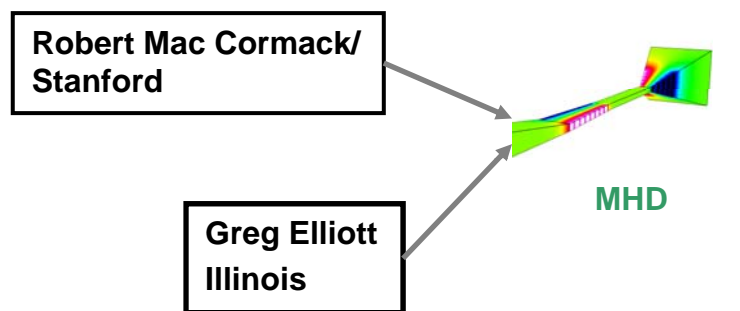
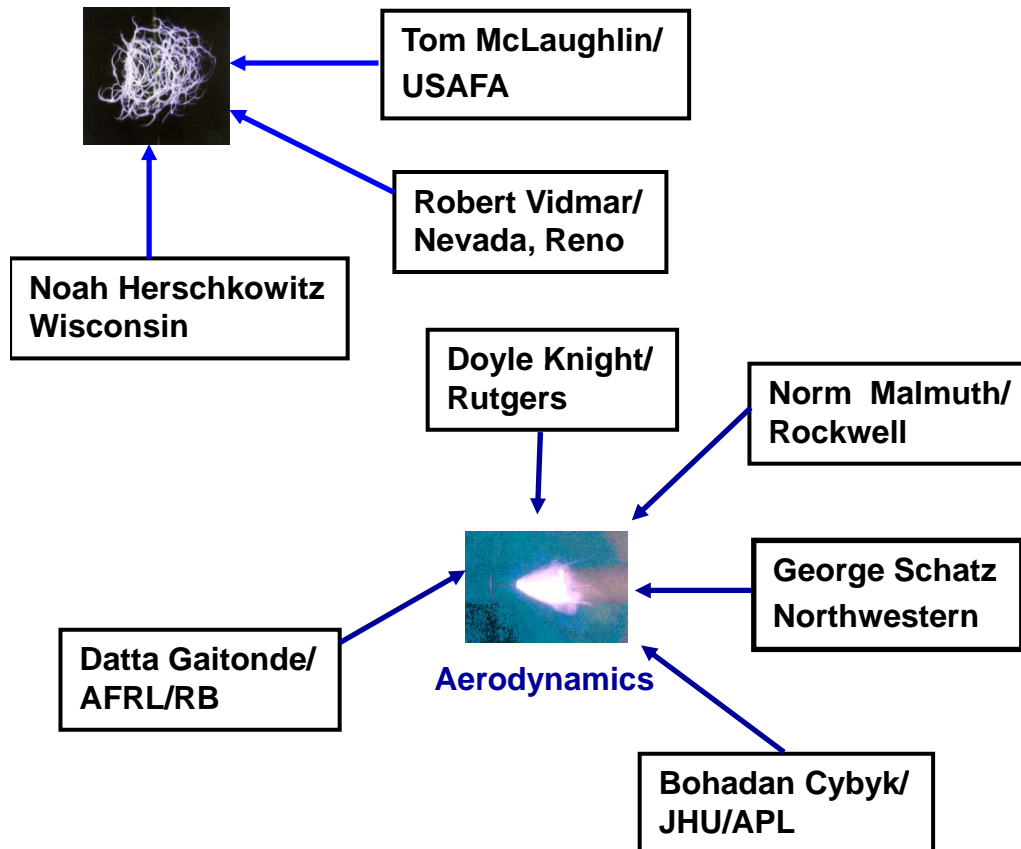


PLASMA DYNAMICS FOR AEROSPACE APPLICATIONS



U.S. RESEARCH AFOSR PLASMA THEME

Plasma Generation

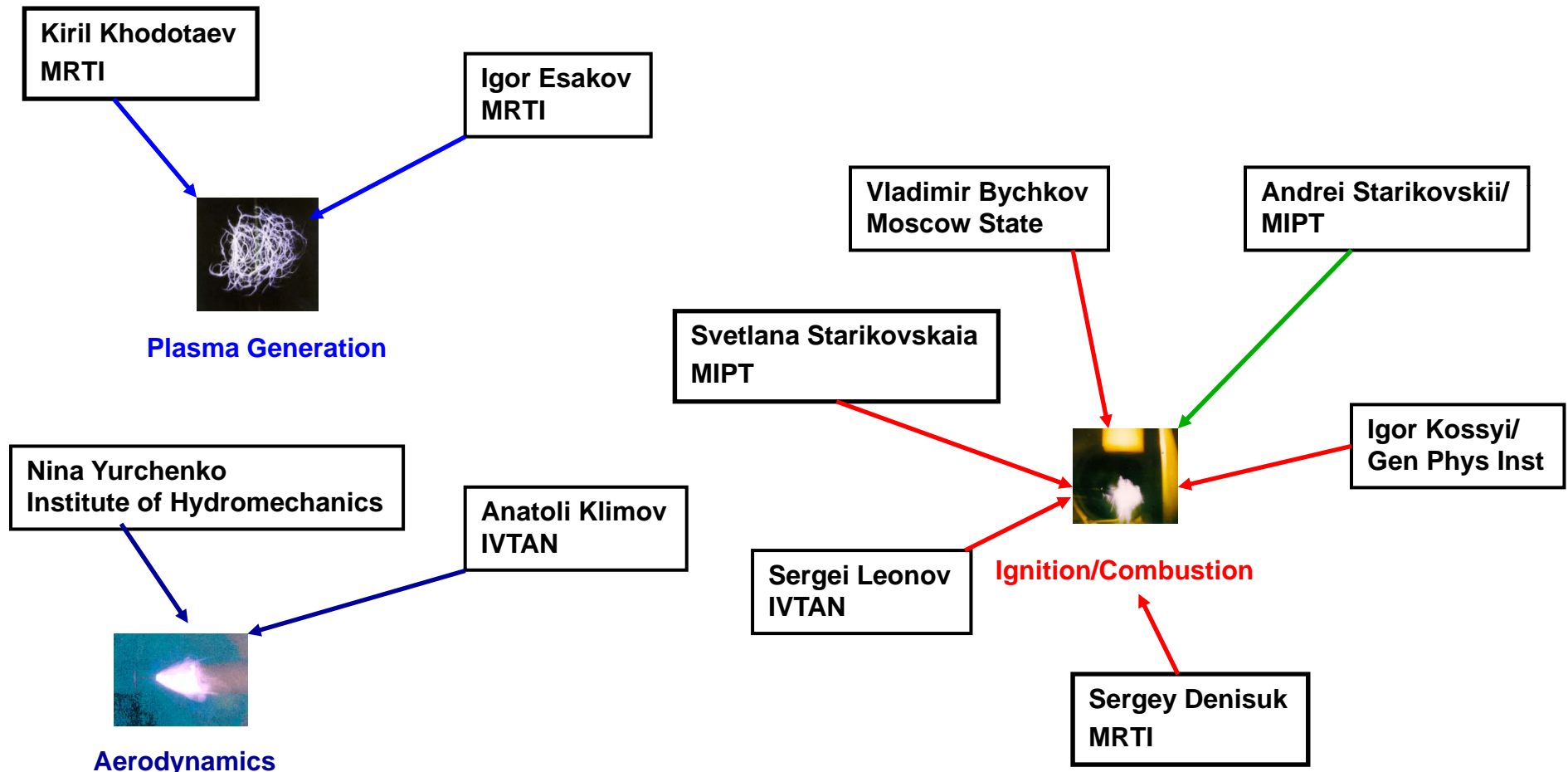




PLASMA DYNAMICS FOR AEROSPACE APPLICATIONS



RUSSIAN/UKRAINIAN RESEARCH

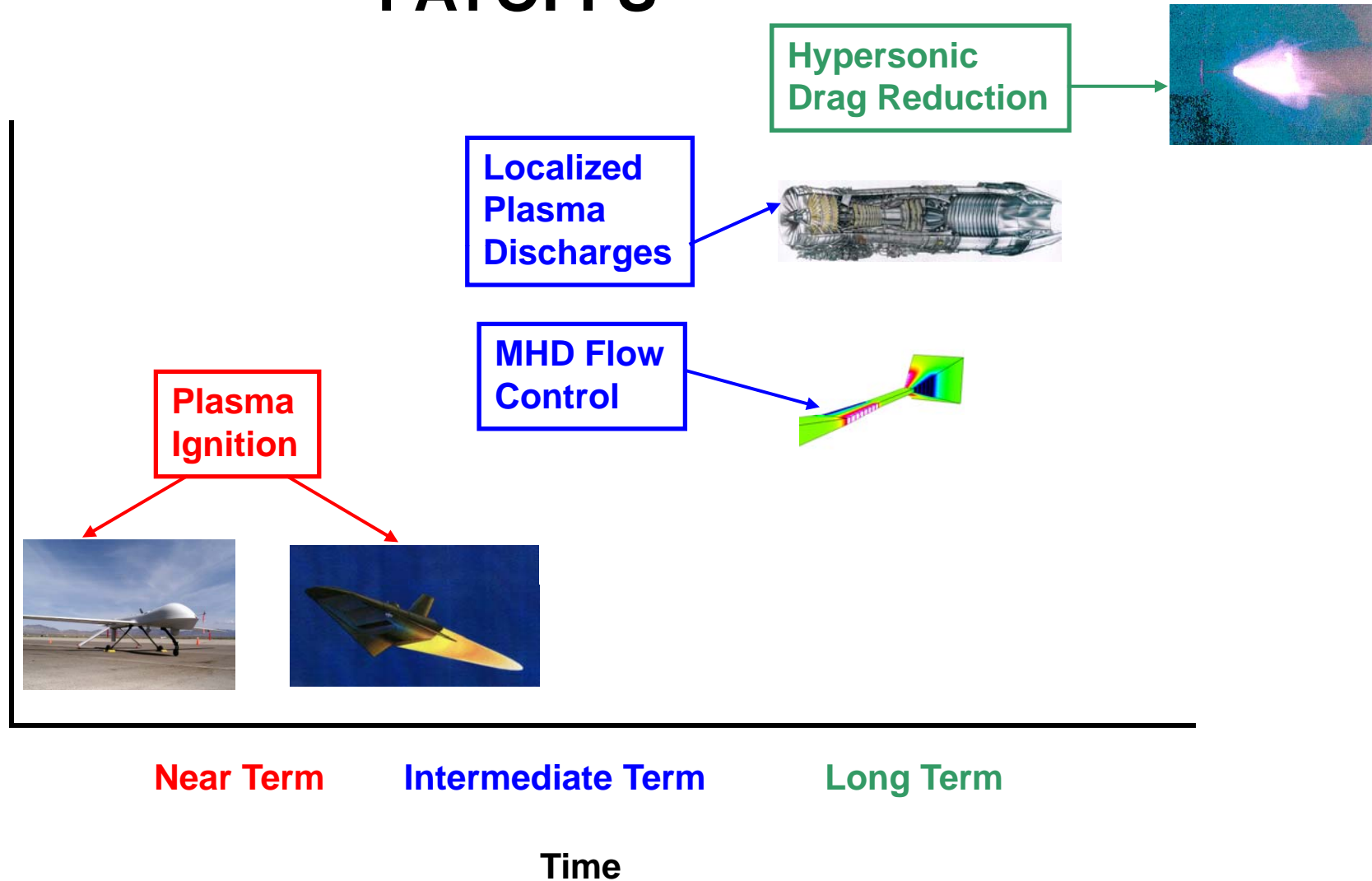




PLASMA DYNAMICS FOR AEROSPACE APPLICATIONS



PAYOFFS





PLASMA-ENHANCED COMBUSTION



2009 MULTIDISCIPLINARY UNIVERSITY RESEARCH INITIATIVE

**CHEMICAL ENERGY ENHANCEMENT BY NONEQUILIBRIUM
PLASMA SPECIES**

The Legacy



PLASMA IGNITION

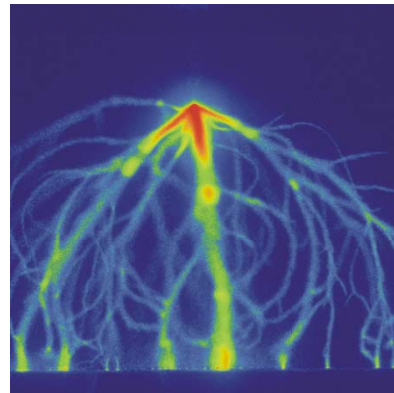


PLASMA IGNITION ALTERNATIVES



Glow Discharge
(Adamovich/Ohio State)

$$dV/dt = 0$$



Streamer Discharge
(Gundersen/USC)

$$dV/dt > 1 \text{ kV}/\mu\text{s}$$



Nanosecond Discharge
(Starikovskii/MIPT)

$$dV/dt > 1 \text{ kV}/\text{ns}$$

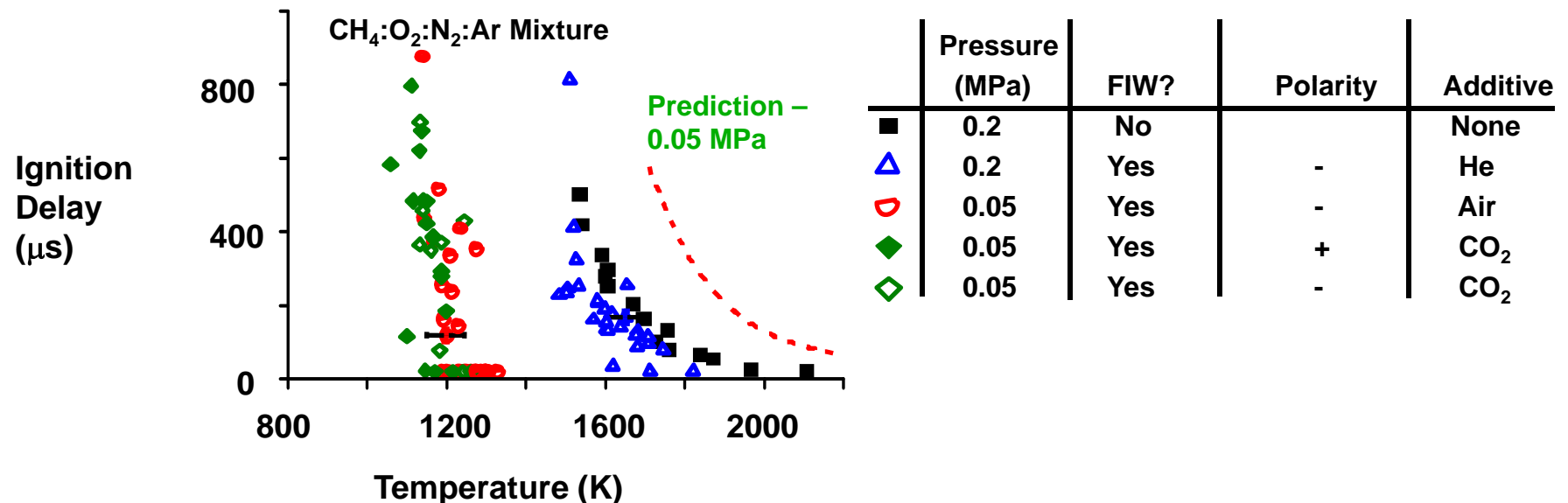


PLASMA IGNITION



SHOCK TUBE EXPERIMENTS DEMONSTRATE IGNITION DELAY REDUCTION BY FAST IONIZATION WAVES

- Results Validate Previous Model Predictions



- Nanosecond Corona Discharge at 0.2 MPa Pressure And By Volume Nanosecond Discharge At 0.05 MPa Pressure
- Ignition Not Possible Without Fast Ionization Wave At 0.05 MPa Pressure

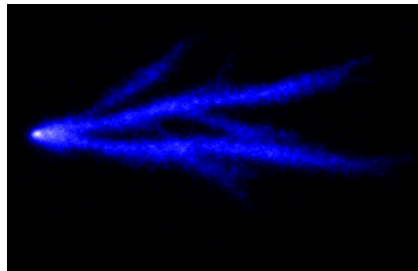


PLASMA IGNITION

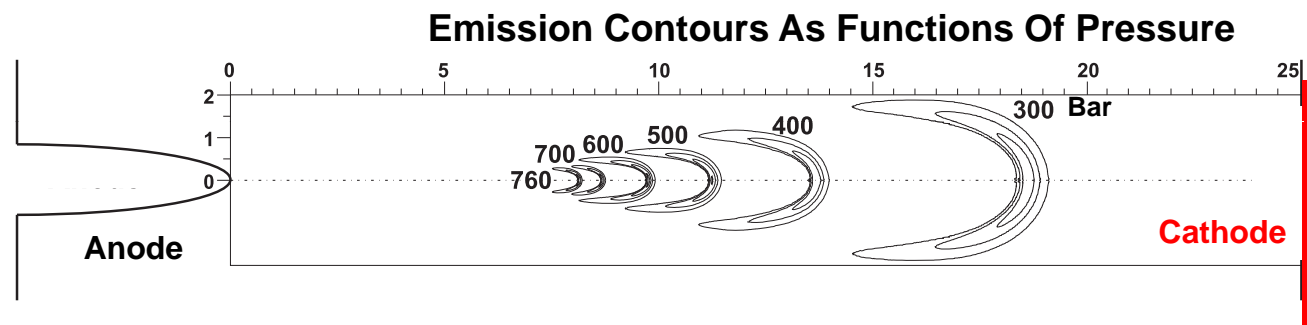


PLASMA STREAMER DISCHARGES MODELED

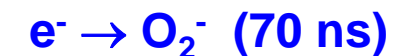
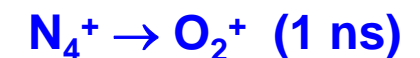
- Provides Initialization For Calculations Of Plasma-Enhanced Combustion



Plasma Streamer Discharge Image



Excitation Chemistry



- Modeling Based On Solving Transport Equations For Primary And Secondary Electrons
- Experimental Validation Through Measurements Of Electric Field Strength For Streamer Discharges In Oxygen-Nitrogen Gas Mixtures

Starikovskii/MIPT

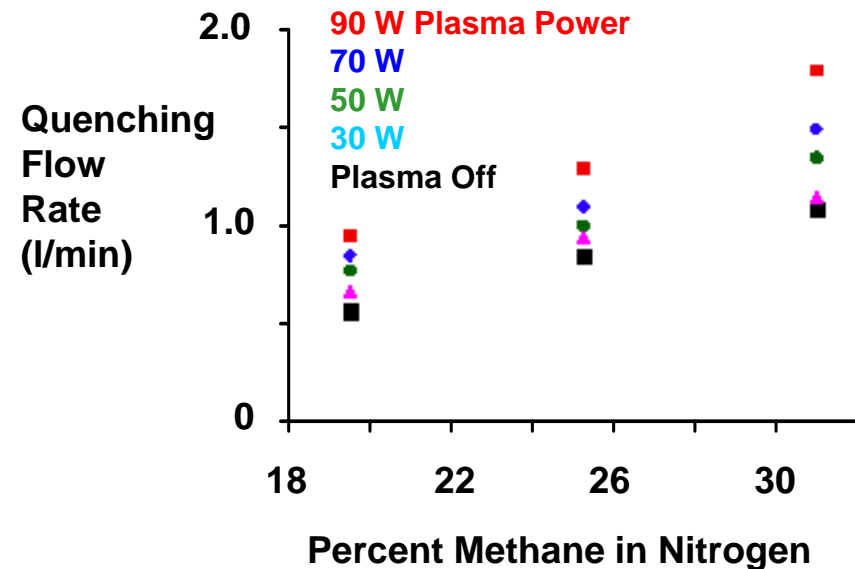
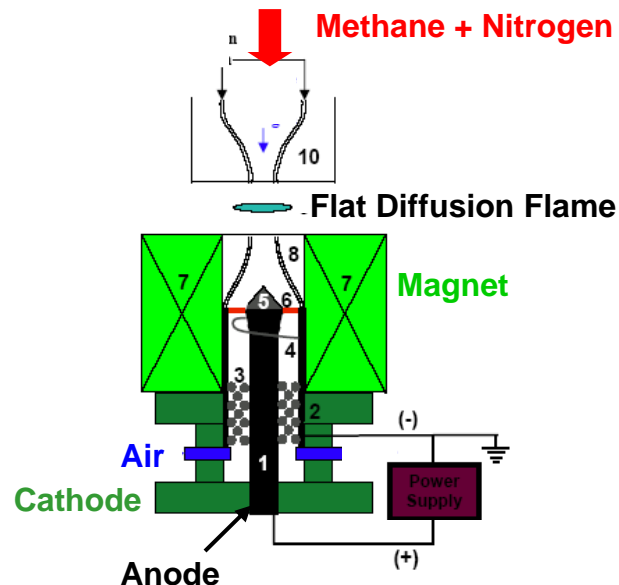


PLASMA-ENHANCED COMBUSTION



100% INCREASE IN DIFFUSION FLAME QUENCH VELOCITY GRADIENT REALIZED WITH GLIDING ARC DISCHARGE

- Means To Stabilize Combustion In Scramjets



- Gliding Discharge Initiated By Helical Inner Electrode And Stabilized Near The Quenching Limit By Field From A 0.15 Tesla Magnet, Producing 20-50 Hz Rotation
- Plasma-Based Thermal Addition Found To Be Negligible, Implying Non-Thermal Plasma Stabilization



COMBUSTION AND DIAGNOSTICS



QUESTIONS?

